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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Su Il Choi, et al. Application No.: 10/606,529 Filed: June 26, 2003 For: **BANDWIDTH ALLOCATION DEVICE AND DYNAMIC BANDWIDTH ALLOCATION METHOD BASED ON CLASS OF SERVICE IN ETHERNET PASSIVE OPTICAL NETWORK**	Examiner: Guerssy Azemar Art Unit: 2613 Confirmation No.: 5763

DECLARATION PURSUANT TO 37 C.F.R. §1.131

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

I, Jae Doo Huh, hereby declare that:

1. I am a citizen of Korea.

2. I currently reside at 107-1303 Hanarum Apt., Wolpyung-dong, Seo-gu, Daejeon, Republic of Korea.

3. I am currently an employee of Electronics and Telecommunications Research Institute.

4. I have been employed by Electronics and Telecommunications Research Institute since Feb. 1987.

5. My position at Electronics and Telecommunications Research Institute is Project Leader of Sensor Networking Research Team.

6. I am a co-inventor of the above-identified patent application.

7. I have assigned my rights to the above-identified patent application to Electronics and Telecommunications Research Institute.

8. Co-inventor Su Il Choi and I submitted the attached article "Dynamic Bandwidth Allocation Algorithm for Multimedia Services over Ethernet PONs to ETRI Journal on June 28, 2002 for publication.

9. The article describes the subject matter of the rejected claims 1-3 in the above-identified patent application.

10. The submission date (June 28, 2002) of the article is prior to the priority date (September 13, 2002) of the cited reference Haran (U.S. Publication No. 2005/0249497) on which the rejection is based.

I hereby declare that all statements made herein of my own knowledge are turn and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the above-identified application or any patent issued thereon.

Respectfully submitted,

Dated: 16. APR, 2007

Jae Doo Huh

REQUEST FOR EVALUATION OF DOCUMENT

(1303) Networking Technology Team, Access Technology Research Department, Network Research Institute Tel: 6678/ In charge: Su-Il Choe

Document No.: 1300-2002-0115
Project No.: 02MT2203
Date prepared: June 25, 2002

In charge		Team head	General Manager

1. Title	Korean	이더넷 수동광통신망에서 멀티미디어 서비스를 위한 동적 대역할당 알고리즘			
	English	Dynamic Bandwidth Allocation Algorithm for Multimedia Services over Ethernet PONs			
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3. Security category	A: writer/ department head		Protection period	Until the date described/published	
4. To be published by (in detail)	Name	ETRI Journal			
	Class	International (Country: Korea)		Published/described	Published Described
	Supervising body	ETRI		Examination by supervising body	Yes No
	Applicability of SCI/SSCI/SCI Expanded Journal: Yes No				
5. Expected date	Expected date to be delivered outside	June 28, 2002		Expected publication date	December 31, 2002
6. Particulars for protection	Is there any invention or design in the document to be protected as an intellectual property right? Yes No				
	If so, have you taken any actions? Applied Expected to apply (Date: July 15, 2002)				
	Patent management No./title in case you applied	Management No.: ( )			
		Title:			
		Application No.: ( )			
		Registration No. ( )			
7. Name of project	S/W technology research for access system				
8. Indexes	Access system, DBA, Ethernet PON, MPCP (Separated by comma)				

9. Abstract (within 500 words)

Ethernet PONs offer a new alternative as a low-cost access network. The Ethernet PONs are implemented by connecting an optical access line between a central office and subscribers. The thesis suggests a dynamic bandwidth allocation (DBA) algorithm to realize a multimedia service in the Ethernet PONs. To achieve the DBA algorithm, a bandwidth is processed based on class of service in a multi-point control protocol (MPCP) through a control message.

Management No.: PR200201416 Classification: 1	In charge	Team head
Date received: July 9, 2002		
Received by: Business Development Team		

원고심의 의뢰서

(1303)네트워크연구소 액세스기술연구부 네트위킹기술팀 Tel:6678 / 담당:최수일

문서번호 : 1300-2002-0115
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담당		팀장	부장

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	영 문	Dynamic Bandwidth Allocation Algorithm for Multimedia Services over Ethernet PONs			
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	SCI / SSCI / SCI Expanded 저널 해당 여부 : 해당됨 해당안됨				
5. 예정일자	외부발송예정일	2002.06.28.	발표예정일	2002.12.31.	
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	있다면 조치사항은? 기신청 신청예정 (신청예정일 : 2002.07.15.)				
	기 신청시 특허 관리번호/명칭	관리번호 : ( )			
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		출원번호 : ( ), 등록번호 : ( )			
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8. 색인어	Access System, DBA, Ethernet PON, MPCP, (색인어는 ,로 구분)				

9. 초록 (한글 500자 이내)

이더넷 수동광통신망 (Ethern PONs)은 저가형의 액세스 망의 새로운 대안으로 제시되고 있다. 이더넷 수동광통신은 중앙국사와 가입자사이에 광액세스 라인을 연결하여 구성된다. 본 논문에서는 이더넷 수동광통신망에서 멀티미디어 서비스를 위한 새로운 동적대역할당 (DBA) 알고리즘을 제안한다. 제안한 동적대역할당 알고리즘을 구현하기 위하여 다중점 제어 프로토콜 (MPCP)에서 서비스 분류에 따른 대역을 처리하는 제어 메시지 형태를 제시한다.

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관리번호 : PR200201416		등급 : 1 등급		
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Dynamic Bandwidth Allocation Algorithm for Multimedia Services over Ethernet PONs

Su-il Choi and Jae-doo Huh

ABSTRACT— Ethernet PONs are an emerging access network technology that provide a low-cost method of deploying optical access lines between a carrier's central office and a customer site. In this paper, we propose a new algorithm of dynamic bandwidth allocation for multimedia services over Ethernet PONs. To implement suggested dynamic bandwidth allocation algorithm, we present control message formats that handle classified bandwidths in multi-point control protocol of Ethernet PONs.

I. INTRODUCTION

The only effective solution to the last mile bottleneck is a universal fiber based infrastructure that is accessible to both businesses and residences. A Passive optical network (PON) is a point-to-multipoint optical network with no active elements in the signals' path from source to destination. This PON technology is viewed by many as an attractive solution to the last mile problem [1], [2].

PONs consist fundamentally of an optical line terminal (OLT) located at the central office (or cable headend), and multiple remote optical network units (ONUs) that deliver broadband voice, data and video services to subscribers. In the downstream transmission, the OLT broadcasts frames and ONUs selectively receive frames addressed to themselves. In the upstream transmission, time division multiplexing access (TDMA) is used to avoid frame collisions. Each ONU transmits frames to the OLT using timeslots exclusively assigned to itself.

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There is a simple TDMA scheme in which every ONU gets a fixed timeslot [3]. While this scheme is very simple, it had a drawback that no statistical multiplexing between the ONUs were possible. An OLT-based polling scheme called interleaved polling with an adaptive cycle time (IPACT) [4] uses an interleaved polling approach where the next ONU is polled before the transmission from the previous one has arrived. This scheme provides statistical multiplexing for ONUs and results in efficient upstream channel utilization. Although, this algorithm is not suitable for delay and jitter sensitive services or service level agreements (SLAs) because of a variable polling cycle time.

We propose a dynamic bandwidth allocation (DBA) algorithm for multimedia services over Ethernet PONs. Quality of service (QoS) does increase the effectiveness of existing bandwidth by prioritizing among packet classes and delivering time-sensitive packets first. Hence, we classified services into three priority categories. To implement suggested dynamic bandwidth algorithm, we present control message formats which handles classified bandwidths in multi-point control protocol (MPCP) of Ethernet PONs.

Section II describes proposed DBA algorithm based on service classification. Section III presents control message formats of MPCP protocol to implement suggested DBA algorithm. Finally, some concluding remarks are given in section IV.

II. DYNAMIC BANDWIDTH ALLOCATION

1. Service Classification Strategy

Quality of service (QoS) is a general concept that incorporates a number of strategies to help deliver data network traffic

in an ordered manner, thereby reducing the impact of packet delay when transmission demand exceeds network capacity.

We classify services into three priority categories:

First, the high priority delivery service is intended to support application which require bounded end-to-end delay and jitter specifications. For example, it will be used for voice and constant bit rate (CBR) video services with low jitter requirements. The media access control (MAC) assumes that traffic requesting high priority service will be shaped at ingress to meet provisioned values for committed information rate (CIR), burst information rate (BIR), and excessive information rate (EIR) by the MAC client [5].

Second, the medium priority service is provided to implement a traffic class for applications, which are not delay sensitive but which require bandwidth guarantees. It will be used by time-constrained CBR services as well as real time variable bit rate (VBR) services that require a guaranteed capacity and bounded jitter but present small burstiness. It is similar in implementation to the high priority service in a way that it expects the client to provide shaped ingress traffic stream that conforms to provisioned CIR and EIR limits.

Lastly, the low priority service is provided to implement a best effort traffic class (BETC). It is not sensitive to end-to-end delay or jitter.

2. Dynamic Bandwidth Allocation Algorithm

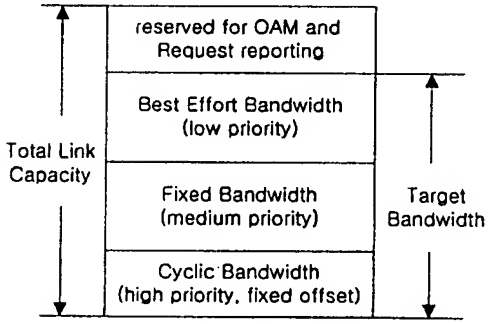

Fig. 1. Ethernet PON bandwidth.

Because Ethernet traffic is bursty by nature, time division multiplexing (TDM) is not automatically supported. TDM service requires cyclic nature, low latency, and low jitter. Hence, DBA for Ethernet PON requires special considerations for TDM. Cyclic bandwidth is need for TDM services [6]. OLT assigns upstream bandwidth based on the categorized user traffics. The composition of Ethernet PON bandwidth is shown in Fig. 1.

We suggest a new DBA algorithm as follows:

Let n be the number of ONUs which are discovered automatically, B_{total} be the total bandwidth, B_{target} be the target bandwidth, and B_{betc} be the bandwidth for best effort traffic class. This algorithm updates grant values periodically using the information from ONUs.

Step 1. The high priority delivery bandwidth, GH_i, is assigned for services which require bounded end-to-end delay and jitter specifications. The GH_i has cyclic property which implies a fixed offset time. The GH_i is obtained as

$$GH_i = RH_i, \quad 1 \le i \le n \tag{1}$$

where RH_i is the high priority request bandwidth from i-th ONU. RH_i is obtained based on the queue lengths of several high priority services, or based on the SLAs for each ONU. The operations administration and maintenance (OAM) and bandwidth request information can be handled as high priority services. In this case, GH_i should contain additional bandwidth for OAM and bandwidth request reporting.

Step 2. The medium priority grant bandwidth GM_i is assigned for services, which are not delay sensitive but require bandwidth guarantees. The GM_i is obtained as

$$GM_i = RM_i, \quad 1 \le i \le n \tag{2}$$

where RM_i is the medium priority request bandwidth from i-th ONU.

Step 3. The low priority bandwidth GL_i is assigned for best effort traffic class. It is not sensitive to end-to-end delay or jitter. By using (1) and (2), B_{betc} is obtained as

$$B_{betc} = B_{target} - \sum_{i=1}^{n}(GH_i + GM_i) \tag{3}$$

Then, GL_i is obtained as

$$GL_i = \begin{cases} RL_i & when \ \sum_{i=1}^{n} RL_i \le B_{betc} \\ \dfrac{RL_i}{\sum_{i=1}^{n} RL_i} B_{betc} & when \ \sum_{i=1}^{n} RL_i > B_{betc} \end{cases} \tag{4}$$

where RL_i is the low priority request bandwidth from i-th ONU.

III. MULTI-POINT CONTROL PROTOCOL

The multi-point control protocol (MPCP) specifies a control mechanism between a master unit and slaves units connected to a point-to-multi-point (P2MP) segment to allow efficient

transmission of data. MPCP is defined within the MAC control layer which provides for real-time control and manipulation of MAC sublayer operation. Control messages for MPCP are GATE, REPORT, REGISTER_REQ, REGISTER, and REGISTER_ACK. In Ethernet PONs, Point-to-point (P2P) emulation is used for compliance with IEEE 802.1 standard.

2. Control Messages

We suggest GATE and REPORT message formats for useful multimedia services over Ethernet PONs.

GATE message provides for time stamps broadcasting, ONU discovery, continuous ranging, and dynamic time slot allocation. The slot allocation technique is a variable TDMA scheme based on allocating a variable number of continuous time-slots to ONU's based on their slot requests or SLAs.

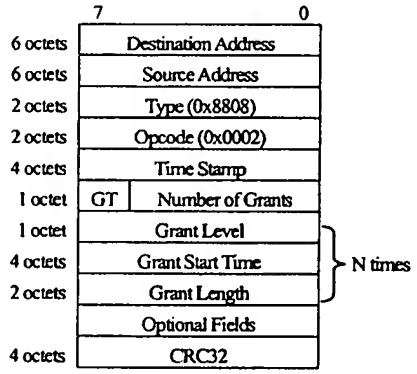

Fig. 2. GATE message.

GATE message format is shown in Fig. 2. OLT generates periodically time stamped GATE messages to be used as global time reference. For discovery of unknown ONUs, OLT multicasts GATE message to all registered and unregistered ONUs. In this case, destination address contains reserved multicast address (IEEE802.3 full duplex PAUSE: 01-80-c2-00-00-01). OLT assigns individual grant windows to registered ONUs by specifying grant level, grand start time, and grant length fields. GATE message contains multiple grants for each ONU. Grant level is divided into low priory (LP), medium priority (MP) and high priority (HP).

Fig. 3 shows REPORT message format. REPORT messages are generated in ONU MAC control client. ONU transmits frames during assigned grants and requests additional bandwidth using REPORT messages. Hence, REPORT message provides multiple bandwidth request information of each ONU.

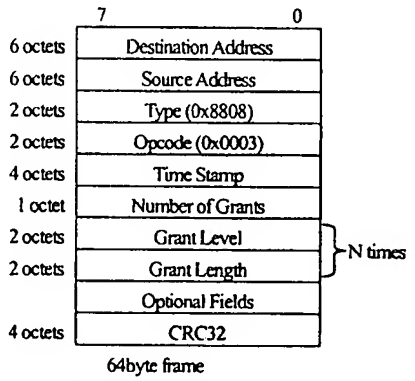

Fig. 3. REPORT message.

2. MPCP Allocation

A centralized scheduler called MPCP allocator performs MPCP allocation. MPCP allocator transmits and receives control frames using MAC control primitives. Fig. 4 shows functional blocks of OLT and ONU. Slot counter of MPCP allocator counts bandwidth request information of each ONU. Then, Grant generator generates grants for each ONU, and transmits grants using GATE message. Grant operates similar to a PAUSE mechanism defined in IEEE 802.3 standard. ONU only transmits frames during the time indicated in the grant. MPCP requestor of each ONU checks multiple buffering status and request bandwidth using REPORT message. ONU MAC control enables physical layer transmission at the start of a grant duration and disables it at the end of the grant duration by using SingnalIndication() function.

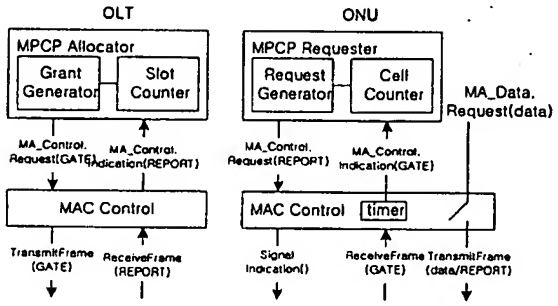

Fig. 4. Functional blocks of OLT and ONU.

3. Link Efficiency

In the Ethernet PON architecture, 1490 *nm* and 1310 *nm* wavelengths are used in the downstream and the upstream directions respectively. The packets are formatted according to the IEEE802.3 standard and are transmitted downstream at 1 *Gbps* . Link efficiency is impacted by number of ONUs in a PON due to the need for guard bands separating traffic from

different ONUs.

Assuming that gate-report cycle is 2 $m$sec, guard-band is 1 μsec, 16 / 32 / 64 / 128 ONUs are connected to a PON. A single logical link identification is assigned for each ONU. Table 1. shows downstream and upstream overheads, which shows that overheads for DBA of Ethernet PON are negligible.

Table 1. Downstream and upstream overheads.

No. of ONUs	Downstream overhead	Upstream overhead	
	GATE	Guardband	Guardband+REPORT
16	0.4 %	0.8 %	1.2 %
32	0.8 %	1.6 %	2.4 %
64	1.6 %	3.2 %	4.8 %
128	3.3 %	6.4 %	9.7 %

IV. CONCLUSIONS

We proposed a new DBA algorithm that efficiently manages various kinds of user traffics by categorizing them into three types. This DBA algorithm is suitable for multimedia services. We also presented control message formats of MPCP protocol for implementation of suggested DBA algorithm in Ethernet PONs.

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